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Time preferences and health behaviour: a review

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Abstract

In this paper, we review published studies to assess the influence of time preferences on human health behaviour. Our review indicates that elicited discount rates for health have been found to be higher than those for money in both the social and private context. We discuss the importance of discount rates for public policy since high time discount rates can contribute to governmental emphasis on acute health care, rather than preventive health care. We then examine how time preferences interrelate with specific health concerns such as smoking or obesity. We find that even when time preferences are elicited in the monetary domain, they can be successful in predicting smoking cessation and likewise for obesity. We also discuss how time preferences relate with teen risk taking behavior.

JEL codes: D91, I0

Keywords: Time preference; Health domain; Risk aversion; Discount rate; Health behaviour

Introduction

Often in life, individuals are faced with the choice of immediately consuming or waiting to consume a good. In other words, one chooses between immediate gratification and delayed gratification. Usually, when one chooses to wait, it is because through waiting, one may be able to receive a larger reward. For example, saving money to buy a new car can both *earn interest* while the money is being saved *and save interest costs* once the car is purchased. Through waiting, one is able to save money and then use it to gain additional utility through the consumption of additional goods. This exemplifies the concept of time preference. Standardly defined, time preference is the amount of future utility that is equivalent to the current utility of consuming a good or service. Time discount rates express the amount of future utility necessary to compensate an individual for waiting.

Research on time preferences and health outcomes has conventionally had applications in shaping public policy, explaining psychological decision making, and uncovering motivations behind seemingly irrational health behaviours (Chapman 2003). Indeed, time preferences play a major role in the ways our decisions shape our health and our lives. Understanding the impact of time preferences and how to best capture them is a primary goal of time preference research. Much work on time preferences has focused on theoretical modeling (see Andersen et al. 2011, for a review of the alternative models that have been proposed in the literature as well as on a plethora of empirical applications). In a well cited paper, Frederick et al. (2002) provided a review of the historical origins of the discounted utility model, biases that occur when

measuring time discount rates, and methods of measuring discount rates, some of which Chapman (2003) has addressed as well. This paper will not attempt to repeat either of these comprehensive works; rather, they are complemented here through a review of post-2002 work that profiles the influence of time preferences on human (health) behaviour. Specifically, our objectives in this paper are:

1) Explain how the societal time discount rate differs from the private time discount rate;
2) Determine how time discount rates sway governments;
3) Assess how time discount rates affect decision making in regard to risky behaviours such as becoming obese, smoking, and engaging in risky sexual behaviour; and
4) Discuss the repercussions of time preferences on prevention of poor health.

In general, the time preference literature should be of particular importance to agricultural and food economists whenever an inter-temporal trade-off decision is at place. This would cover much of everyday food consumption (e.g., eat this piece of cake now vs. postpone eating it), to agricultural farming decisions (e.g., how much of the underground water reserves to use today) as well as health-related decision making (e.g., smoking decisions).

The articles included in our review are related to either social or private discount rates, time preferences and the developing world, or risky health behaviour.[a] We also included papers with time preference and human behaviour components. Given the review by Frederick et al. (2002), papers published before 2002 were sometimes included to explain results from works published during or after 2002.

Review

Current time preference elicitation methods

Frederick et al. (2002) identified field and laboratory experimental studies as the two main categories of research on time preference. In laboratory experimental studies, the elicitation mechanisms used include choice tasks, matching tasks, rating tasks, and pricing tasks. On one hand, field studies, can represent real world behavior, although the likelihood of confounds is high due to the difficulty in controlling all factors that affect time preferences. An example of a field study is the work by Shanmugam (2006), in which discount rates were estimated using data about the risk levels in certain jobs in India.

Among the experimental elicitation mechanisms (i.e., choice, matching, rating, and pricing) typically used in time preference lab studies, choice tasks (i.e., discrete choice experiments) are the most common (Frederick et al. 2002). In these tasks, individuals choose between a smaller, more immediate award and a more desirable delayed award. Sometimes, these choices are made in the monetary domain and then compared to actual health-related behavior (Chesson et al. 2006). Alternatively, the choices relate to hypothetical health scenarios in which participants much choose their most preferred option (Hardisty and Weber 2009).

Matching tasks are also referred to as open-choice experiments, which usually entail a “fill in the blank” approach (Frederick et al. 2002, p. 387). Participants are given a scenario and must find the delayed equivalent of that scenario (Frederick et al. 2002).

Responses to hypothetical health scenarios have been compared with other behaviors such as smoking status (Khwaja et al. 2007).

Unfortunately, the experimental elicitation mechanism itself can contribute to differing measured time discount rates as a meta-analysis study has shown (Percoco and Nijkamp 2009). A comparison of close-ended and open-ended time preference elicitation mechanisms showed that close-ended mechanisms elicit lower mean discount rates, although there is consistency between social and private discount rates and between discount rates and individual traits (van der Pol and Cairns 2002).

In rating tasks, individuals indicate how attractive a particular situation is. When this type of method is compared to others, the way in which individuals use the scale and the elicitation method has been shown to explain some of the variance in time preference studies, although health states seem to explain the largest percentage of variance (Essink-Bot et al. 2007). Less commonly used are pricing tasks in which individuals are asked how much they are willing to pay for a specified event at a specified time.

All of these methods have advantages and disadvantages, some of which are perhaps more pronounced in the health domain. The next section explores some weaknesses of the current methods and potential improvements for the next generation of time preference elicitation methods.

Possible improvements to time preference elicitation methods

There are several issues which make time preference elicitation methods for health outcomes less straightforward than those for monetary outcomes. For one, elicitation mechanisms that involve monetary trade-offs can be made non-hypothetical because researchers can choose to make one or all of the choices made in the experiment binding.[b] On the other hand, health tradeoffs can only be hypothetical in nature due to a number of ethical and practical reasons. For instance, a scientist cannot enforce the choices one makes about health in a time preference experiment. Frederick et al. (2002) reviewed the limited studies that have compared hypothetical and non-hypothetical outcomes. In one case, the discount rates from the hypothetical treatments were lower, but the hypothetical and non-hypothetical experiments were designed differently (Kirby and Maraković 1995). In a second case, the discount rates were lower for real treatments only when censoring was not taken into account (Coller and Williams 1999).

Conceivably, when hypothetical health states are described to participants, some of those participants have experienced a wider array of health states and thus may be able to better imagine the state being described. This may be especially true when the hypothetical state is supposed to represent an actual condition, and the subjects in the study have had or have that condition. For example, in a study which attempted to determine willingness to pay for a quality adjusted life year (QALY) when the temporary health state was shingles, those who had suffered from shingles in the past were willing to pay more (Lieu et al. 2009). Likewise, those who have experienced an adverse condition place more importance on avoiding it than others who have not experienced the condition (Baron et al. 2003). This shows that there may be a relationship between experience and the way individuals respond to a specific hypothetical health state with which they have had experience. Perhaps there is also a relationship between those who have had more experience with a wider array of health states and how they respond in these choice tasks. This may come through age, for example. A sixty-five year old who has

had heart disease has more experience with negative health states than a healthy twenty-five year old that has never had a serious condition or experienced a long hospital stay. Certainly, there are some twenty-five year olds that have had serious health issues and have more experience than some sixty-five year olds, so this is not a strict example. Controlling for this experience is a difficult task because the concept is somewhat difficult to define in mathematical terms. Perhaps one could use a proxy such as days stayed in a hospital overnight or frequency of illness. To our knowledge, this has not been done before but could be an interesting point for future research.

Additional methods that can be used for time preference elicitation in the health domain could be borrowed from time preference elicitation methods used in the monetary domain. For example, Andersen et al. (2008) presents non-hypothetical elicitation methods for both time and risk preferences. A risk preference elicitation task is included because risk aversion can be a potential confound in time preference analysis (i.e., risk aversion affects the curvature of the temporally dated utility function). In all of these methods, subjects are presented with a series of choices. In the risk tasks, one choice represents lesser risk with lesser reward and the other choice represents greater risk with greater reward. Subjects who are less risk averse will more consistently choose the riskier gambles. For explanatory purposes, a series of monetary gambles is shown in Table 1.

We would expect risk seeking individuals to choose Option B in the first few rows and risk averse individuals to choose Option B in the last few rows. The number of times someone chooses Option A before switching to Option B could be used as simple index of risk aversion.[c] In its simplest form, this number can be added as a covariate in regression models such as those used in willingness to pay studies. The lotteries shown in Table 1 are on the lower end of order of magnitudes. Additional tables with tasks of higher order of magnitudes are typically presented.[d] To eliminate hypothetical bias, one row from one set of tasks can be randomly selected as binding.

The elicitation format in Table 1 is known as a Multiple Price List (MPL) format. Andersen et al. (2008) used a MPL to elicit time preferences as well. For the time preference elicitation task, subjects choose between two options (a monetary example is shown in Table 2). One option is more immediate but has a smaller reward. The further down a subject changes from Option A to Option B, the higher his or her time discount rate is. Like in the risk preference exercise, this number could be a covariate in regression

Table 1 An example of a risk preference elicitation task

Option A	Option B
10% chance of winning $2, 90% of winning $1.60	10% chance of winning $3.85, 90% of winning $0.10
20% chance of winning $2, 80% of winning $1.60	20% chance of winning $3.85, 80% of winning $0.10
30% chance of winning $2, 70% of winning $1.60	30% chance of winning $3.85, 70% of winning $0.10
40% chance of winning $2, 60% of winning $1.60	40% chance of winning $3.85, 60% of winning $0.10
50% chance of winning $2, 50% of winning $1.60	50% chance of winning $3.85, 50% of winning $0.10
60% chance of winning $2, 40% of winning $1.60	60% chance of winning $3.85, 40% of winning $0.10
70% chance of winning $2, 30% of winning $1.60	70% chance of winning $3.85, 30% of winning $0.10
80% chance of winning $2, 20% of winning $1.60	80% chance of winning $3.85, 20% of winning $0.10
90% chance of winning $2, 10% of winning $1.60	90% chance of winning $3.85, 10% of winning $0.10
100% chance of winning $2, 0% of winning $1.60	100% chance of winning $3.85, 0% of winning $0.10

Table 2 An example of a time preference elicitation task

Option A	Option B
$300 in 1 month	$305 in 4 months
$300 in 1 month	$310 in 4 months
$300 in 1 month	$315 in 4 months
$300 in 1 month	$320 in 4 months
$300 in 1 month	$325 in 4 months
$300 in 1 month	$330 in 4 months
$300 in 1 month	$335 in 4 months
$300 in 1 month	$340 in 4 months
$300 in 1 month	$345 in 4 months
$300 in 1 month	$350 in 4 months

models and replace a myriad of time preference proxies. Alternatively, one can estimate explicit risk aversion coefficients and discount rates at the individual level using structural econometric methods. A series of tasks, each with differing orders of magnitude, can be used. The exercise can be made non-hypothetical using the random lottery incentive mechanism.

Table 2 presents a MPL of dated amounts of money that correspond to a three month time horizon. Most often, additional tasks are also administered that vary the time horizon of the payoffs. In this particular example, both the sooner and the latter option are delayed. The delay in the sooner amount of money is called a front-end delay (FED) and has some advantages: first, it avoids the passion for the present that decision makers exhibit when offered monetary amounts today or in the future; and second, it allows the researcher to equalize the credibility of future payments. A third advantage is that it holds the transaction costs of future options constant in case these are not negligible (see for example the discussion in Coller and Williams 1999). If one decides not to use a FED, then extra care is needed in order to equalize transaction costs across all time periods, including physical costs. Andreoni and Sprenger (2012) describe six specific measures to equate transaction costs and ensure payment reliability.

Time preferences and domain independence

Individuals make intertemporal choices and express preferences in several domains including health, money, and the environment. Researchers have found that monetary and environmental domains may be comparable (Hardisty and Weber 2009). However, correlations between health and money domains tend to be generally low and researchers refer to this phenomenon as domain independence. Domain independence may be problematic because, according to normative discounted utility theory, discount rates should not change with decision domain (Chapman 2003). For individuals, these differences do not appear to be a result of different utility functions for health and money (Chapman 1996) or familiarity with health situations (Chapman et al. 1999). Possibly, individuals do not consider health and money 'fungible', or tradable. In public health policy, however, health and money are more easily viewed as fungible because in this case, policy makers are making monetary investments to garner future health benefits (Chapman 2003). Not surprisingly, the issue of domain independence is a point of

contention in the literature. If money and health are tradable, then the same discount rate can be used for both domains. However, since it is conceivable that individuals may not value their health and money in the same way, then arguments for using differential discount rates seem warranted. Lazaro (2002) reviewed arguments for both concepts and concluded that neither can be fully accepted without reservation. Lazaro suggests, however, that empirical evidence should be the determinant in choosing which framework to adopt. For example, Lazaro et al. (2002) examined the time preferences of a representative Spanish sample and found that health outcomes are discounted at a higher rate than monetary outcomes.

The literature suggests that a contributing factor to domain independence is the temptation associated with a particular domain. For example, beer drinkers who are not chip lovers have high discount rates for beer but low discount rates for chips in part because they are *more tempted* by beer. The increased visceral attraction to a particular domain may entice a "hot" state, similar to what a cigarette addict experiences when s/he craves a cigarette (Tsukayama and Duckworth 2010).

Societal and private time discount rates

Time preferences play a critical role in developing public health policy. When we speak of time preferences and public policy, we must distinguish between individual time preferences and social time preferences. Private time preferences refer to an individual's decisions, while societal time preferences refer to society's preferences for others' well-being. When making public policy decisions, the social discount rate is usually regarded as an appropriate measure to use (Drummond et al. 1987; Olsen 1993). Some studies have shown that discount rates for health were higher than those for money in both the social and private context (Lazaro et al. 2001, 2002), although more recent evidence indicates that social time discount rates for health were lower than social time discount rates for money (Meerding et al. 2010). As Cairns (2001) points out, the differences could be attributed to differing sample populations or differing methods of framing time preference. For example, in the case of higher discount rates for health, there is the possibility that when health outcomes are delayed, subjects are less certain of those outcomes than they are when the delay is associated with monetary outcomes (Chapman 2003). Social and individual discount rates *within the health domain*, however, seem to be similar (Cairns and van der Pol 2000; van der Pol and Cairns 2002).

Another issue to consider when using time preferences to develop public policy is the concept of intergenerational time preference, or in other words, how the utility of the current generation is to be weighed against the utility future generations will experience. The role of the government to protect future generations at the expense or sacrifice of the current generation that elected it, is a point of debate (see Frederick 2006 for a review). Perhaps most important to understand is that the individual discount rate and the intergenerational discount rate are not readily interchangeable.

Time preferences and governments

Understanding time preferences is vital to understanding governmental policy. For example, high time discount rates contribute to governmental emphasis on acute care, rather than preventative care. Of course, there are facets of governmental policy other than time preferences that can further complicate public policy decision making. Subsidizing

treatments and fee-based systems contribute to inefficiency through the overuse of some treatments and overconsumption of treatments in general, respectively (Watts and Segal 2009). Understanding these interplaying factors can help frame the discussion of public policy.

Developing and developed countries generally have specific public policy decisions that are partially explained by time preferences. Time preferences can help explain how countries make allocation decisions to specific programs. An example is the AIDS pandemic in Eastern Africa, considered one of the biggest public policy challenges in the developing world. Prevention strategies include the development of an AIDS vaccine and the distribution of condoms. Governments with high societal discount rates do not readily invest in prevention while governments that value the future would have low discount rates and would be likely to invest in prevention. For example, distribution of condoms as a prevention strategy, is only cost effective if the condoms are distributed to specific at-risk groups (Fleßa 2003).

Developed countries can also face similar dilemmas, although they usually deal with non-pandemic situations when it comes to health. Some recent results from a large-scale international survey on time discounting conducted in 45 countries indicate strong evidence for cultural differences, as measured by the Hofstede cultural dimensions (Wang et al. 2011). In this study, high levels of "Uncertainty Avoidance" or "Individualism" were both associated with strong hyperbolic discounting.

We summarized the published health discount rates in developing countries in Table 3. Robberstad (2005) elicited time discount rates from Tanzanians for a hypothetical health state linked to malaria. Discount rates were lower for the more severe malarial-like illness, which would be evidence of an absolute magnitude effect where higher discount rates are associated with smaller outcomes (Andersen et al. 2013). Robberstad (2005) suggested that separate discount rates for non-fatal and fatal illnesses are perhaps more appropriate than assigning one discount rate to each condition. Evidence for the magnitude effect and the common difference effect[e] (where time preference rates and time spans are inversely correlated) was demonstrated in a similar study that compared several discounting models (Robberstad and Cairns 2007). This study found that hyperbolic discounting models specifically those of Mazur (1987) and Loewenstein and Prelec (1992), fitted the data better. In this example, the authors observed that the choice of model could have significant implications on final public policy decisions. Namely, the discounted utility model at a 3% discount rate more heavily emphasized immediate health solutions than did the hyperbolic model (Robberstad and Cairns 2007).

In addition to analyzing time discount rates, identifying factors that relate to discount rates is an important area of research. A study which was performed in South Africa, an area "with high morbidity and mortality", found that health and survival probability had significant relationships with subjective discount rates (Chao et al. 2009). Those in very good health, very poor health and those who expressed great certainty or uncertainty about how long they would live, had high discount rates. In other words, health and survival probability had a u-shaped relationship with the subjective discount rate (Chao et al. 2009).

In developed countries such as the United States, investment in health research can potentially improve health outcomes across the income spectrum by improving treatment

Table 3 Estimates of health discount rates for developing countries

Mean private discount factor (P_d)	Mean social discount factor (S_d)	Delay of condition	Elicitation method	Model	Sample size	Health state description	Hypothetical?	Country	Study
0.071	0.068	3-6 yrs	Open-ended stated preference	Discounted utility	n = 224 for $\mathbf{P_d}$ n = 226 for $\mathbf{S_d}$	Malarial-like disease	Hypothetical	Tanzania	(Robberstad 2005)
0.122*	0.122*	3-6 yrs	Open-ended stated preference	Harvey (Hyperbolic)	450 pooled sample	Non-fatal but will miss work	Hypothetical	Tanzania	(Robberstad and Cairns 2007)
0.101*	0.101*	3-6 yrs	Open-ended stated preference	Mazur (Hyperbolic)	450 pooled sample	Non-fatal but will miss work	Hypothetical	Tanzania	(Robberstad and Cairns 2007)
0.121*	0.121*	3-6 yrs	Open-ended stated preference	L&P (Hyperbolic)	450 pooled sample	Non-fatal but will miss work	Hypothetical	Tanzania	(Robberstad and Cairns 2007)
0.076-0.079	N/A	Age and life expectancy (from tables) considered for each individual	Real-life job choices and associated risks	Expected discounted life years lost by weighted non-linear least squares	522	N/A	Non-hypothetical	India	(Shanmugam 2006)

*Pooled both social and private discount rates because there was no statistical difference.

options or better defining a healthy lifestyle (Rosenman 2011). Similarly, investment in preventative measures such as the AIDS vaccine could have great value in developing nations. Understanding the interplaying psychological factors that contribute to changes in time preference is critical for establishing appropriate public policy.

Time preferences and risky behaviour

Countries are continually faced with public health concerns, particularly because their citizenries often undertake risky health behaviours. Among these are smoking, being overweight or obese, and participating in risky sexual behaviour, which all contribute to government expenditures on healthcare. Sexual education programs designed to decrease risky sexual behaviour, anti-smoking initiatives, and anti-obesity campaigns are common in many countries due to the financial burdens that these behaviours incur.

In many western countries, obesity is an especially challenging public health issue. Food-related patterns/habits and their relationship to time preferences is potentially important because intertemporal food choices affect behaviours that can lead to obesity. For example, preferences for immediate gratification over future health benefits contradict most weight control methods that require forgoing current consumption of unhealthy foods. Knowledge of the specific factors that drive time preferences can therefore be an important tool in shaping public health policies related to food consumption (e.g., Komlos et al. 2004; Smith et al. 2005; Zhang and Rashad 2008).

Time preferences and obesity

In the United States, the obesity problem is of primary importance because obesity is the second leading cause of preventable deaths (Mokdad et al. 2004) due to its contribution to higher incidences of heart disease and diabetes (Colditz 1992). The figures are comparable for Europe. The rise of obesity is often attributed to technological change, although some authors have also suggested that an increase in time preference rates is also to be blamed (Lakdawalla and Philipson 2009; Philipson and Posner 2003; Komlos et al. 2004).

When judging whether a change in time preference has increased obesity rates, many measures of impatience are usually examined. These measures are considered time preference proxies. Among these are savings rates, which have fallen, and credit card debt, which has risen (Blaylock et al. 1999). To further examine the relationship between personal savings and obesity, Komlos et al. (2004) compared obesity prevalence and lagged personal savings in the US and found that as obesity increased by 112%, personal savings fell by 83% during the last three decades of the twentieth century. Additionally, obesity prevalence and lagged debt-to-income ratio showed similar trends; the debt-to-income ratio accelerated during the 1980s and 1990s as did obesity prevalence. When comparing countries, those with higher net domestic savings rates have lower incidences of obesity and vice-versa. The culmination of this evidence supports the likely relationship of time preference and obesity, although the authors caution that causal relationships cannot be determined from it. More work is needed to explain why certain subgroups (e.g., women) have more prevalent obesity rates than others (Komlos et al. 2004).

In Table 4, we summarize the time preference proxies and elicitation methods used in the obesity studies discussed in this review.

Table 4 Time preference proxies and elicitation methods in obesity studies

Study	Subject	Elicitation Method/Proxies
(Ayyagari et al. 2011)	Diabetes Management (Obesity)	Agreement to "I live life one day at a time and don't think much about the future"
(Sloan et al. 2009)	Diabetes Management (Obesity)	Agreement to "I live life one day at a time and don't think much about the future"
(Zhang and Rashad 2008)	Obesity	Time preference proxies: degree of willpower and "desire but no effort"
(Komlos et al. 2004)	Obesity	Time preference proxies: Savings and debt-to-income ratio
(Huston and Finke 2003)	Obesity	Time preference proxies: "Level of formal education, smoking, exercising and using nutrition labels on a regular basis, and the degree of nutrition knowledge…"

Time preferences and smoking

Smoking presents an especially interesting case study because of the persistently high smoking rates in many countries. We first review the theories under which individuals make the decision to smoke in light of its potentially negative consequences. We then discuss related work from UK, the United States, Japan, and Korea.

Cawley (2008) and Sloan and Wang (2008) discuss three economic models which attempt to explain an individual's choice to participate in addictive behaviour: perfectly rational addiction (introduced by Becker and Murphy 1988), imperfectly rational addiction, and irrational addiction. Cawley (2008) synthesizes addictive behaviour into three important tenets: tolerance, withdrawal, and reinforcement. Tolerance drives dissatisfaction with the current level of consumption. Withdrawal contributes to an aversion of quitting because of the negative feelings associated with cessation. Reinforcement encourages increasingly higher consumption because individuals continually derive satisfaction from consuming an extra unit of a good. Ferguson (2006) provides a very detailed discussion about the rational theory of decision-making in the health domain.

The imperfectly rational model can be partially explained in terms of hyperbolic discounting, which, unlike exponential discounting, accounts for changing time preference rates. Under hyperbolic discounting, smokers experience an increasing time discount rate as cessation approaches. Besides time-inconsistent preferences, under the imperfectly rational model, individuals may also "misperceive probabilities of harms following from their current behaviours, have cognitive difficulties in forming probabilities or learning from the experiences of others, and/or have imperfect information about their own probabilities of becoming addicted" (Sloan and Wang 2008, p .1778). Under the irrational addiction model, decisions about consuming addictive substances are motivated by emotion, rather than logic. Empirical evidence supports the rational and irrational models. For example, cigarette prices influence consumption, which could be indicative of either model type, although impulsivity seems to influence current smokers, which is not consistent with the rational model (Sloan and Wang 2008). Overall, the best fitting theory has not been determined, although evidence has been shown to support facets of each. More empirical work is necessary to fully understand the theoretical underpinnings behind addiction.

Data collected from older English adults attempted to define the relationship between smoking cessation and time preferences (Adams 2009b). The authors found that as

subjects' financial planning periods increased, the chances of smoking decreased, though quitting cessation did not show the same pattern. In this study, subjects were classified by their responses to the question "In planning your/your family's saving and spending, which of the following time periods is more important to you and your husband/wife/partner?" (Adams 2009b, p. 530). Their choices ranged from the next few weeks to longer than 10 years. As Adams (2009b) points out, this question is more related to the monetary domain while smoking cessation is related more to the health domain. Scharff and Viscusi (2011) found that the implied time discount rate of smokers was higher than that of nonsmokers (i.e., smokers were less future-oriented than non-smokers) by examining the income individuals received compared to the danger associated with their job. This method also potentially fails to truly isolate the health and monetary domains since as previously discussed, time preferences could change for different domains. Additionally, a number of omitted variables may be confounding the analysis, which includes severity of addiction, smoking-associated-disease diagnosis, self efficacy, information and ideas about the ill-effects of smoking, and social support among others (Ward et al. 1997). Smoking and time preferences are interrelated with information and education to the extent that Fersterer and Winter-Ebmer (2003) used smoking status at age 16 to predict future educational attainment. One must note, however, that not all studies find a significant relationship between time discount rates and smoking. For example, Harrison et al. (2010), find that male smokers have significantly higher discount rates than male non-smokers, but smoking has no significant effect on discount rates among women, which may be attributed to differences in the elicitation method (Khwaja et al. 2007).

When considering time preferences and their role in smoking (especially with regards to smoking cessation), one should also consider risk aversion, or the likelihood an individual will take on more risk in exchange for the possibility of a larger reward (risk aversion directly affects the concavity of the utility function, see for example Andersen et al. 2008). Studies using samples of Japanese individuals have found that lower time discount rates (i.e., more future orientation) and risk aversion predicted quit success significantly (Goto et al. 2009; Ida and Goto 2009b). The discrete choice method, in which subjects choose between two different combinations of attributes, allows joint consideration of risk and time preferences and estimation of actual discount rates and risk aversion coefficients. A higher time preference rate and lower risk aversion coefficient was associated with increased likelihood of smoking (Ida and Goto 2009a, b). The discrete choice method offers more information than studies which use time preference proxies to determine associations between behaviours and time preferences (Goto et al. 2009). Additionally, use of time preference proxies can potentially confound the analysis because some behaviours (e.g., smoking) that are associated with time preferences may also be associated with risk aversion.[f] Besides smoking, other conditions or behaviours such as having too much body weight, not wearing a seatbelt, and drinking heavily have been found to have significant, negative relationships with risk aversion (Anderson and Mellor 2008). It is therefore quite difficult to separate time preferences and risk aversion when using proxies.

Through the examination of studies that relate the behaviour of smoking with time preferences (see Table 5), we find that one of the most important questions asked in these studies is how to increase the efficacy of smoking cessation programs and prevent

Table 5 Time preference proxies and elicitation methods in smoking studies

Study	Subject	Elicitation Method/Proxies
(Scharff and Viscusi 2011)	Smoking	"Workers' wage fatality risk trade-offs" (Implied time discount rate for nonsmokers was 8.1% compared to 13.8% for smokers)
(Ida and Goto 2009b)	Smoking	Discrete choice experiment to measure time and risk preferences
(Adams 2009b, p. 530)	Smoking	Response to "In planning your/your family's saving and spending, which of the following time periods is more important to you and your husband/wife/partner?"
(Goto et al. 2009)	Smoking	Discrete choice experiment to measure time and risk preferences
(Khwaja et al. 2007, p. 935)	Smoking	Financial Intertemporal Choices; Health Intertemporal Choices (e.g. "20 extra days in perfect health this year would be just as good as __ extra days in perfect health *x* year(s) from now")
(Fersterer and Winter-Ebmer 2003)	Smoking and Education	Smoking status at 16 years of age

more individuals from ever starting. Although the practical implementation is not clear, an important step mentioned is increasing future orientation (Adams 2009b) and thus instigating a lower discount rate. Hence, the direction public policy should take, may depend on the theoretical framework that supports addictive behaviour. If smoking addiction operates under the rational addiction model, then public service programs designed to communicate the harm that smoking causes to others and self might be beneficial. On the other hand, under the imperfectly rational and irrational models, individuals will most likely regret their present choices later; thus devices designed to promote self-control in the present, such as increased smoking taxes and smoking bans, may be helpful. These devices would also be beneficial under the rational addiction model (Sloan and Wang 2008). Analysis of successful anti-smoking programs should offer guidance into these policies' effectiveness. For instance, efforts from the Korean government in the early twenty-first century seemed to improve quit success and intention. Among their efforts were the combined effects of increased cigarette taxes and anti-smoking campaigns (these were not evaluated separately in the model) (Hong and Collins 2010). In addition, the study demonstrated the role of promoting general healthy behaviour in public policy. Individuals who exercised more and were moderate drinkers were found to be more likely to intend to quit smoking (Hong and Collins 2010).

The interplay between time preferences, health behaviour, and socioeconomic status

The literature discussed above is highly suggestive of a link between time preference and health-related statuses such as smoking habits (or lack thereof) and obesity. The issue addressed here is the interplay among these behaviours in light of potentially confounding demographic considerations (summarized in Table 6). In one study, socioeconomic status (as measured by the Index of Multiple Deprivation) was significantly related to time preferences (as measured by the Consideration of Future Consequences Scale), smoking status, and BMI (Adams and White 2009). Specifically, time preferences were found to affect socioeconomic status and BMI, though not smoking status. In contrast, Adams (2009a) found that socioeconomic status has a role in determining

Table 6 Time preference proxies and elicitation methods in combined smoking and obesity studies

Study	Subject	Elicitation method/proxies
(Cutler and Lleras-Muney 2010, p. 17)	Health behaviour including smoking and obesity	Health Intertemporal Choices: "20 extra days in perfect health this year would be just as good as extra days in perfect health *X* years from now? where *X* was 1, 5, 10 and 20."
(Adams 2009a, p. 796)	Smoking, Obesity (by physical activity)	Response to "In planning your (family's) saving and spending, which of the following time periods is more important to you and (your partner)?"
(Adams and White 2009)	Smoking, Obesity	Consideration of Future Consequences Scale
(Robb et al. 2008, p. 1673)	Smoking, Obesity	Time preference index: "diet choice, vitamin use, education, smoking status, exercise, nutritional knowledge, use of nutrition labels and importance of nutrition"

the level of physical activity and smoking status. Time preferences were also shown to not account for any of the education gradient, e.g., the association between the education chasm and health behaviours including smoking and being overweight (Cutler and Lleras-Muney 2010). This finding reinforces the importance of examining time preferences in light of confounding variables such as socioeconomic status as in Adams and White (2009) or income, family structure, or health insurance status as in Cutler and Lleras-Muney (2010).

The relationship between BMI and smoking *per se* is highly important as well. The vast majority of longitudinal and cross-sectional work finds an inverse correlation between smoking and BMI (Klesges et al. 1989), though much of this work fails to account for the mitigating effects of time preferences. Since time preference has been found to be an important predictor of BMI (Robb et al. 2008), exclusion of time preferences in studies examining the link between BMI and smoking can be confronted with omitted variable bias.

Time preferences and sexual behaviour

Risk-taking sexual behaviours contribute to societal costs both in terms of monetary expenditures on treating sexually transmitted diseases (STD) (e.g., herpes simplex virus, HIV, etc.) and the human suffering associated with these diseases. Chesson et al. (2006) examined the relationship between time discount rates and sexual behaviour. They found that risky sexual-behaviour-indicators such as 'having gonorrhea or Chlamydia', 'having sex before age 16′, and 'pregnancy status' were all significantly associated with high discount rates. In addition, discount rates were found to decrease with age, which is in accordance with findings that teenagers greatly discount the future and show little regard for future health consequences (O'Donoghue and Rabin 2001). Thus, programs which stress the short-term consequences of STDs may be more effective in encouraging young people to pursue healthier choices.

Time preferences and prevention

Knowing that time preferences are related to human behaviours is not enough. Rather, if we can understand what motivates people psychologically when making intertemporal choices, we can utilize what we know about time preferences to positively affect public health and in some cases predict occurrence of diseases. A prevalent public policy issue

that affects many nations is vaccine programs, which have been used to control many diseases that once wreaked havoc around the world. Analyzing the introductions of new vaccine programs through time preference measurements is an effective way of gauging their cost effectiveness.

A meta-analysis performed by Chapman (2005) demonstrates that 'hot' or addictive health behaviours such as smoking have been found to be more associated with time preference than 'cold' behaviours such as vaccination. Other prevention behaviours designed to prevent cervical and breast cancer, such as self-breast exams, mammograms, and Pap smears, are associated with individuals with higher life expectancy, lower time preference, and more risk aversion (Picone et al. 2004). Differences in education and cognitive ability may also partially explain differences in health behaviours including participation in prevention behaviours (Cawley and Ruhm 2011). The educated may be better informed about risk factors for a particular disease (e.g., breast cancer (Chen and Lange 2008) or perhaps better able to process information from government-funded prevention campaigns (e.g., HIV/AIDS prevention campaigns in Uganda (de Walque 2007)).

Nevertheless, the distinction between hot and cold behaviour states plays a major role in the irrational model of decision making. Hot or visceral states such as hunger or craving have been shown to decrease future orientation (Loewenstein 2005). Individuals with addictions have experienced more hot states than non-addicts, which might also contribute to decreased future-orientation even when not in hot states. Chapman (2005) suggests that time preferences are associated with only some health behaviours. Therefore, time preferences may be capturing part of another psychological component such as impulsiveness or temptation-withstanding-ability, though strong evidence exists for the association between time preference and smoking in particular. Understanding what contributes to the decision to smoke is of great importance when it comes to cancer control, since smoking is a significant risk factor for cancer.

Of course, environmental factors, other than smoking, can contribute to cancer. Thus, individuals often associate programs designed to promote cleaner environments with reduced disease risks. The costs that individuals are willing to pay today to reduce the risk of disease in the future can be determined using contingent valuation methods. For example, in Taiwan, individuals were asked how much they were willing to pay in increased utility costs to promote cleaner water (and thus a lesser chance of liver disease) and in increased cost of consumer goods to promote cleaner air (and thus a lesser chance of lung disease). In both instances, the disease either occurred in a few months or 20 years later. If the negative consequences are delayed, willingness to pay to avoid disease will decrease most likely due to present-biased time preferences. It is also noteworthy that willingness to pay (WTP) is dependent on disease type (cancer vs. non-cancer), the combination of the organ type (liver vs. lung), environmental pathway (water vs. air), and payment method (utility bill vs. consumer goods) (Hammitt and Liu 2004).

Like time preference elicitation methods, WTP elicitation methods are discussed heavily in the literature. Incorporating WTP in a study that also considers time preference is another step in the direction of considering all the interplaying processes that contribute to human behaviour and decision making.

Conclusions

In this review, we tried to demonstrate the important role time preferences play in our everyday lives and in terms of health behaviour in particular. Specifically, we tried to synthesize the more recent empirical literature on time preferences in the health domain.

Our literature review illuminates several interesting results as well as potential venues for future research. First, there is a need for more research that will explore if and how elicited discount rates in the monetary domain can be applied in the health domain. There are some indications that time preferences for health may be domain independent and distinct from time preferences for monetary rewards. However, discount rates elicited from monetary tasks have the advantage of being elicited under real circumstances (i.e., they have real economic consequences) while normally this is not possible for discount rate tasks that are health domain specific. In this respect, our review indicates that elicited discount rates for health have been found to be higher than those for money in both the social and private context. Social and individual discount rates *within the health domain*, however, seem to be similar but still distinct from those for monetary outcomes.

Our review also emphasizes the importance of discount rates for policy making since high time discount rates can contribute to governmental emphasis on acute health care, rather than preventive health care. Therefore, providing policy makers with accurate estimates of societal and/or individual discount rates is extremely important given that discount rates reflect society's preferences on how scarce resources should be utilized. It is also important to remember that the social discount rate, which considers society's preferences for others' wellbeing may not be interchangeable with the individual time discount rate, which considers an individual's preferences for himself or herself. Context may also partially determine the influence of time preferences. For example, time preferences in developing countries may exhibit differing trends from those of developed countries.

When it comes to specific health concerns like obesity and smoking, our review shows that there is likely a relationship with time preference, although causality can be an issue in these types of studies. Some studies have shown that even when time preferences are elicited in the monetary domain, they can be successful in predicting smoking cessation or that time preferences along with risk aversion can predict smoking quit success rates. This is important because it provides policy makers with a potential tool on how to increase the efficacy of smoking cessation programs and prevent more individuals from starting to smoke. Similar implications seem to apply for obesity health concerns. The interplay of smoking and obesity with respect to time preferences is important (albeit under-researched) since there might be a combined effect on time preferences. This is supported by the fact that many longitudinal and cross-sectional studies find an inverse correlation between smoking and obesity.

Our review also uncovers how time preferences relate to risky sexual behavior. For example, teenagers have been found to greatly discount the future and show little regard for future health consequences, which is why it is important to address risk-taking sexual behaviors. Perhaps the most important part of this analysis is that by exploring how time preferences change with sexual behavior, one could potentially invent ways that would reduce risky sexual behavior by altering time preferences.

The behavioral economics literature has several tools to offer in the direction of nudging time consistent choices. One such tool, known as commitment devices, has been shown to induce people to become more future-oriented. For example, people that were offered a savings account, which was closed for withdrawals until a pre-set date or amount, accumulated 81% more savings than a control group after twelve months (Ashraf et al. 2006). Another option is to move costs in time. The 'Save More Tomorrow' (SMarT) pension program by Thaler and Benartzi (2004) accomplishes that by moving the start of the contribution to retirement savings from salary increases to the future. The average saving rates for SMarT program participants increased from 3.5% to 13.6% over the course of 40 months. The idea of moving costs into the future has also been successfully applied in the area of charitable giving (Breman 2011). More research on how to effectively structure choice environments that would nudge people to be more future oriented in the domain of health, food and agriculture is indeed warranted.

Endnotes

[a]Our literature review was based on a Web of Science search using the terms "time preference(s)", "behavio(u)r", "smoking", "obesity" and "sex". Several other papers were identified by performing backward literature searches on the papers from our initial list. We are confident that all studies of particular importance in the subject area of our paper were identified and included in the paper.

[b]The issue with having binding decisions in an experiment (i.e., decisions with real monetary consequences) is important since there are evidence of a gap between decisions made under a hypothetical setting and a real setting (e.g., Harrison 2006; Harrison and Rutstrom 2008a). This gap is commonly referred to as hypothetical bias in the relevant literature.

[c]Albeit one can estimate relative risk aversion coefficients using structural econometric methods (Harrison and Rutstrom 2008b).

[d]As Drichoutis and Lusk (Drichoutis and Lusk 2012) note, since this task entails choices made over only four dollar amounts, the task reveals little information about the curvature of the utility function. Thus, it is necessary to scale up payoffs to allow for a wider range of dollar amounts, providing more information on the shape of the utility function. Alternatively, one may want to hold probabilities constant and vary the dollar amounts (Drichoutis and Lusk 2012; Bosch-Domènech and Silvestre 2013).

[e]The magnitude effect and the common difference effect are two of many psychological biases that influence time discount rates; Chapman (2003) further discusses psychological biases.

[f]Andersen et al. (2008) show how risk and time preferences are interrelated. In their experiments they showed that it is essential to have one risk preference elicitation task for measuring the curvature of the utility function, another task to identify the discount rate conditional on knowing the utility function, and then jointly estimate the structural model defined over the parameters of the utility function and discount rate. More recently, Andreoni and Sprenger (2012) extended the methodology proposed by Andersen et al. (2008) by developing a procedure they called the Convex Time Budget (CTB) method that does not require a separate risk aversion task to identify the curvature of the utility function. The procedure involves giving the subject

100 tokens to allocate between the sooner and later time period, and then varying the exchange rate between tokens and money for sooner or later amounts. See also Cheung (2014) for a quibble on Andreoni and Sprenger (2012).

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
All authors have equally contributed to each part of the review study. All authors read and approved the final manuscript

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